Small x Gluons in Nuclei and Hadrons *

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Mini-jet production at high energy is an example where high gluon densities will play an important role. Mini-jets will be important at RHIC and will dominate at LHC over soft phenomena. Nuclear shadowing of initial gluon distribution and high gluon density could significantly reduce the initial mini-jet and total transverse energy production. Such reduced initial energy density will also affect the subsequent parton thermalization. Another example is heavy quark production where high gluon density effects may make a dramatic difference specially at LHC. Since the probability for making a heavy quark pair is proportional to square of gluon density, any depletion in number of gluons will make a significant difference in the number of heavy quark pairs produced.

In this paper we discuss the relation between gluon distributions in nuclei and hadrons follow and numerically solve the generaized DLAP equation for parton density and find out the nuclear modification of the parton distributions.

$$\frac{\partial^2}{\partial y \partial \xi}\, xG(x,Q,b_\perp) = \frac{N_c(N_c-1)}{2}\, Q^2 \left[1 - \frac{1}{\kappa}\exp\!\left(\frac{1}{\kappa}\right) E_1\!\left(\frac{1}{\kappa}\right)\right] \tag{1}$$

where

$$\kappa = \frac{2\alpha_s}{\pi(N_c-1)Q^2}\, xg(x,Q,b_\perp) \tag{2}$$

and $\mathrm{E}_1(x)$ is the exponential integral function defined as

$$\mathrm{E}_1(x) = \int_0^\infty dt\, \frac{e^{-(1+t)x}}{1+t}, \qquad x > 0 \tag{3}$$

We solve the above equation numerically using method of characteristics. We use the following initial conditions,

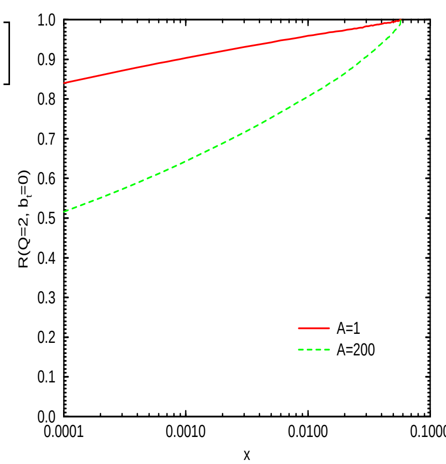
$$\begin{aligned} S_0 &= \ln\left[\frac{N_c\alpha_s}{\pi}\frac{\pi^3}{2Q^2}\, xG(x_0,Q_0,b_\perp)\right] \\ \gamma_0 &= \frac{\partial}{\partial \xi}\, \ln xG(x,Q,b_\perp)|_{x_0,Q_0} - 1 \\ \xi_0 &= \ln Q_0^2 \end{aligned} \tag{4}$$

In the figures, we show the ratio

$$R(x,Q,b_\perp) = \frac{xG^{JKLW}(x,Q,b_\perp)}{xG^{DGLAP}(x,Q,b_\perp)} \tag{5}$$

at $b_\perp = 0$ for both $A = 1$ and $A = 200$ at $Q = 2\ GeV$. We have also taken $R_A = 5\ fm$, $R = 1\ fm$ and $\alpha_s = .25$. Here, xG^{JKLW} refers to solution of the generalized equation while xG^{DGLAP} is the solution of normal DLAP equation. For a proton, we get a $15-20\%$ reduction in the number of gluons at $x \sim 10^{-4}$ as compared to DLA DGLAP while for a Gold or Lead nucleus, there is a $50-55\%$ reduction at $x \sim 10^{-4}$.

The results clearly show the importance of the non-linear terms, specially for a large nucleus, at values of x which will be reached in the upcoming experiments at RHIC and LHC. These non-linear effects will be manifest in terms of shadowing of nuclear gluon distribution function and will have to be taken into account at future high energy heavy ion experiments.



$R(x,Q,b_\perp)$, as defined in (5) at $Q = 2\ GeV$ and $b_\perp = 0$

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